GENERAL LIBRARY
NOV 25 1918
UNIV. OF MICH.

VOLUME 8 NUMBER 11

NOVEMBER, 1918

Phytopathology

Official Organ of the American Phytopathological Society

CONTENTS

Ramularia Root: Rots of Ginseng ..... C. L. Zimmerman 557

The Origin and Spread of Tomato Fruit Rots in Transit ..... J. Rosenbaum 575

Briefer Articles:

Notes on Some Methods and Terms Employed in Studying the Uredinales H. R. Rosen 581

Phytopathological Notes 582

Literature on Plant Diseases 586

PUBLISHED MONTHLY FOR THE SOCIETY

OFFICE OF PUBLICATION

2419-21 Greenmount Ave., Baltimore, Md.

Entered as second-class matter May 16, 1913, at the post office at Baltimore, Maryland, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917. Authorized on July 2, 1918.

Price { $5.00 per year, Domestic
$5.50 per year, Foreign

2169/18—Wolfhuegel's Counting Apparatus, consisting of Counting Plate No. 2169/17 with polished wooden base containing drawer for accessories..... $6.25

2169/24—Novy's Apparatus for Tube Cultures of Anaerobes, by gas or pyrogallate method. In two sizes: 150x20 mm. and 200x160 mm. with and without stopcocks.

SPECIALTIES:

Best Grade of American Glassware, "Non-Sol," "Perfection" and "Pyrex;" H. H. C. Co's. Crimped White Filtering Papers, Filtering Rapidly, specially manufactured for us in America; Swedish and English Filtering Papers; Royal Berlin and Haldenwanger Berlin Porcelain Ware; Best American Porcelain Ware; Troemner and Becker Balances and Weights; Platinum Wire, Foil and Ware; Fused Silica Laboratory Utensils; "Vitreosil;" Hanovia Pure Transparent Quartz Glass; Alundum Ware; Hoskins' Electric Furnaces; Le Chatelier's Pyrometers; Bausch and Lomb Microscopes and Accessories; Hydrometers and Thermometers of every description; Chemically Pure Acids and Ammonia; Merck's, Baker and Adamson's and J. T. Baker Chemical Co.'s Chemicals and Reagents; Caustic Potash and Soda, purified in sticks and pure by alcohol; Acetate of Lead; Cyanide Mixture, Soda Ash and Commercial Caustic Soda.

HENRY HEIL CHEMICAL CO.

210-214 South 4th Street **St. Louis, Mo.**

JORDAN'S *NEW (6th) EDITION*
General Bacteriology

This work deals with non-pathogenic as well as pathogenic bacteria. It has special chapters on the bacteriology of plants and plant diseases—a scientific study of those diseases which destroy flowers, fruits, and vegetables, giving the causes and the means of combating them. There are also chapters on the nitrogen cycle, bacteriology of milk and milk products, of air, agriculture, water, food preservatives, leather tanning, tobacco curing, and vinegar making.

Octavo of 691 pages, illustrated. By EDWIN O. JORDAN, PH.D., University of Chicago. Cloth, $3.75 net.

W. B. SAUNDERS COMPANY
PHILADELPHIA LONDON

INTERNATIONAL CENTRIFUGES

INTERNATIONAL EQUIPMENT COMPANY

352 Western Ave. (Brighton)
BOSTON, MASS.

Catalog Cy. on request

AMERICAN PHYTOPATHOLOGICAL SOCIETY

OFFICERS

1918

President, E. M. FREEMAN,
University Farm, St. Paul, Minn.

Vice-President, C. W. EDGERTON,
Experiment Station, Baton Rouge, La.

Secretary-Treasurer, C. L. SHEAR,
Pathologist, Bureau of Plant Industry, Washington, D. C.

ADDITIONAL MEMBERS OF THE COUNCIL

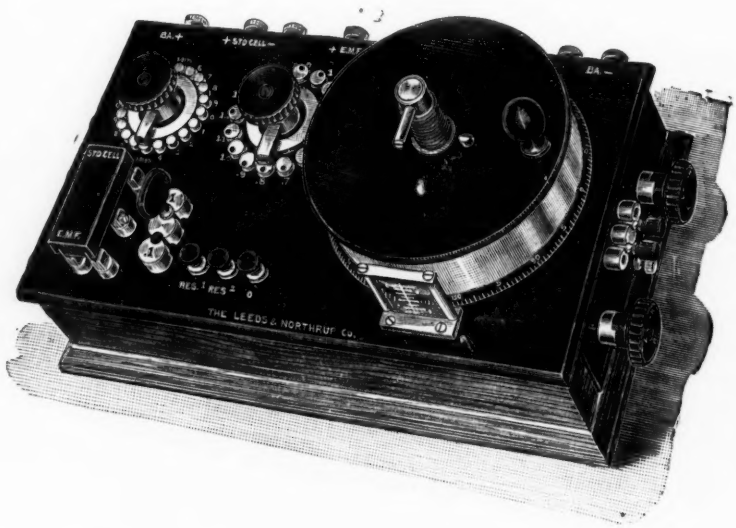
L. R. JONES,
Professor of Plant Pathology, University of Wisconsin, Madison, Wis.

H. S. JACKSON,
Chief in Botany, Purdue University Agricultural Experiment Station, Lafayette, Ind.

MEL T. COOK (*ex officio*),
Plant Pathologist, Rutgers College and New Jersey Agricultural Experiment Station, New Brunswick, N. J.

W. A. ORTON (*ex officio*),
Bureau of Plant Industry, Washington, D. C.

A POTENTIOMETER FOR THE DETERMINATION OF HYDROGEN ION CONCENTRATION IN SOLUTIONS



THE POTENTIOMETER illustrated above is now being used by a number of investigators for measuring the E. M. F. between the Hydrogen and Calomel electrodes in Hydrogen Ion Concentration determinations. It is rapidly replacing the electrometer for such work for the following reasons: first, it is much more sensitive than the electrometer; second, its use does not entail the annoying delays met with in the use of the electrometer when overcharged and thus polarized.

The Leeds and Northrup Potentiometer has two ranges. Normally measurements may be made up to 1.6 volts by steps of .00001 volt. A range changing plug enables measurements to be made up to .16 volt by steps of .000001 volt.

The precision of adjustment is such that on the high range measurements from .1 volt up may be made to a precision of better than 1/50%. On the low range measurements from .01 volt up may be made to the same degree of precision.

The instrument and its accessories require little or no attention. Its manipulation is simple.

A full description of this potentiometer will be sent upon request, as well as a list of some of those who are now using it for Hydrogen Ion Concentration determinations.

THE LEEDS & NORTHRUP CO.

ELECTRICAL MEASURING INSTRUMENTS

4930 STENTON AVENUE PHILADELPHIA

PHYTOPATHOLOGY

THE OFFICIAL ORGAN OF

THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

EDITORS

W. A. ORTON
U. S. Department of Agriculture
Washington, D. C.

E. C. STAKMAN
University Farm
Saint Paul, Minn.

G. P. CLINTON
Agricultural Experiment Station
New Haven, Conn.

ASSOCIATE EDITORS

C. W. EDGERTON, Baton Rouge, La.	One year
H. T. GÜSSOW, Central Experimental Farm, Ottawa, Canada	
N. J. GIDDINGS, Morgantown, W. Va.	
V. B. STEWART, Cornell University, Ithaca, N. Y.	
H. P. BARSS, Oregon Agricultural College, Corvallis, Ore.	Two years
H. A. EDSON, U. S. Department of Agriculture, Washington, D. C.	
G. M. REED, University of Missouri, Columbia, Mo.	
J. B. RORER, Board of Agriculture, Port of Spain, Trinidad.	
J. T. BARRETT, Riverside, Calif.	Three years
F. D. FROMME, Blacksburg, Va.	
W. J. MORSE, Orono, Maine.	
I. E. MELHUS, Ames, Iowa.	

BUSINESS MANAGER

C. L. SHEAR, U. S. Department of Agriculture, Washington, D. C.

EDITORIAL NOTICES

Manuscript for Publication or correspondence relative thereto may be addressed to W. A. Orton or to any other member of the Editorial Board. Contributors are requested, so far as convenient, to carry on preliminary correspondence and submit copy of manuscript to the nearest Associate Editor. For instance, correspondence from Canada may be addressed to H. T. Güssow, from the Pacific coast to H. P. Barss or J. T. Barrett, from the Tropics to J. B. Rorer and so forth.

Manuscripts should be typewritten and carefully revised before submission. While no attempt will be made at exact uniformity in capitalization, punctuation, spelling, citations, footnotes, etc., each contributor is requested to give careful attention to clearness and preciseness in these matters and to conform as far as practicable to the best usage in this journal.

Phytopathological Notes. Manuscript for this department should be sent to H. A. Edson, U. S. Dept. of Agriculture, Washington, D. C.

Reviews. Publications for review should be sent to H. A. Edson, U. S. Dept. of Agriculture, Washington, D. C.

Illustrations. A limited number of illustrations will be accepted. Only the very best photographs can be reproduced satisfactorily by the processes available to the journal. Authors desiring special types of reproduction may be asked to bear part of the expense. Line drawings reproduce very satisfactorily on regular text paper and usually should be submitted for use as text figures rather than as plates. Attention is called to the reproduction of photographs as text figures on a coated paper. For such purposes photographs should be submitted untrimmed and unmounted. Semi-matt printing paper is often preferable to the glossy paper.

BUSINESS NOTICES

Subscription price. $5.00 per year for all points within the United States; foreign subscriptions, $5.50; current single numbers 50 cents. The journal will be issued monthly beginning with Vol. VIII, January, 1918.

Requests to supply lost copies of the journal must be made within 40 days from date of issue. Date of issue January 1 and monthly thereafter.

Separates. No gratis copies are supplied. A printed schedule of prices is submitted with the proof and authors may secure separates by placing an order with the publishers when proof is returned.

Back Volumes may be obtained unbound at $5.00 per volume, postage paid.

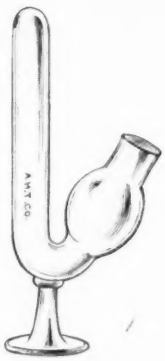
Separate copies will not be sold except in cases where the volumes are already broken. The price of such copies is 85 cents each.

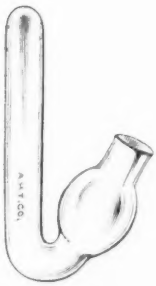
Make all remittances payable to Phytopathology. Address all business correspondence to The Williams & Wilkins Co., 2419-21 Greenmount Ave., Baltimore, or to C. L. Shear, U. S. Department of Agriculture, Washington, D. C.

FERMENTATION TUBES

No. 27588

No. 27592


No. 27600


No. 27604

No. 27608

No. 27617

27588. **Fermentation Tube,** for bacteriological work, small size; height of vertical tube 100 mm., outside diameter of tube 12 to 13 mm.; with long tubulation for plugging and bulb carefully made to hold entire contents of vertical tube; on glass foot, ungraduated. **Each** ..... .35

Per dozen in cartons of 1 dozen 3.78
Per dozen in original cases of 40 dozen 3.36

27592. **Fermentation Tube,** same size and shape as No. 27588 but without glass foot. **Each** ..... .20

Per dozen in cartons of 1 dozen 2.16
Per dozen in original cases of 72 dozen 1.92

27600. **Fermentation Tube, American Public Health Association standard.** See *Standard Methods for the Examination of Water and Sewage.* Inside diameter of upright tube 15 mm., length of vertical tube 140 mm., diameter of bulb 38 mm., on glass foot. **Each** ..... .40

Per dozen in cartons of 1 dozen 4.32
Per dozen in original cases of 18 dozen 3.84

27604. **Fermentation Tube,** same as No. 27600 but without glass foot. **Each** ..... .30

Per dozen in cartons of 1 dozen 3.24
Per dozen in original cases of 72 dozen 2.88

27608. **Fermentation Tube,** without bulb, so-called "fish-hook" form; height of vertical tube 100 mm., outside diameter of tube 12 to 13 mm. **Each** ..... .10

Per dozen in cartons of 2 dozen 1.08
Per dozen in original cases of 144 dozen ..... .96

27612. **Fermentation Tube, Smith,** without foot, designed primarily for the cultivation of anaerobes in exact accordance with the specifications given us by the author; carefully made as to all dimensions and as to the angle between the vertical tube and the bulb, in appearance similar to No. 27604. **Each** ..... .35

Per dozen in cartons of 1 dozen 3.78
Per dozen in original cases of 72 dozen 3.36

27617. **Fermentation Tube, Dunham,** of American Flint Glass, consisting of a culture tube 150x16 mm., with small tube 75x10 mm., without lip, inside. **Per 10 pairs** ..... .36

Per 100 pairs in cartons of 100 pairs 3.24

27618. **Fermentation Tube, Dunham,** same as No. 27617 but with both tubes made of American Resistance Glass. **Per 10 pairs** ..... .44

Per 100 pairs in cartons of 100 pairs 3.96

Prices subject to change without notice

ARTHUR H. THOMAS COMPANY

IMPORTERS—DEALERS—EXPORTERS

LABORATORY APPARATUS AND REAGENTS

WEST WASHINGTON SQUARE PHILADELPHIA, U. S. A.

PHYTOPATHOLOGY

VOLUME VIII NUMBER 11

NOVEMBER, 1918

RAMULARIA ROOT-ROTS OF GINSENG[1]

C. L. ZINSSMEISTER

WITH EIGHT FIGURES IN THE TEXT

Ginseng growers have long been familiar with certain diseases of the root of American ginseng, *Panax quinquefolium* L., to which they have given the popular name, rust. While this term has in all probability been used somewhat indiscriminately for diseases of different origin, there can be little doubt that it has to a large extent served to specify a definite root disease which has come into prominence because of increasing losses due to its presence. The disease was first observed by the writer during the summer of 1913 in a shipment of affected roots from Belleville, Washington. It was also noted in 1914, by Rosenbaum on roots from Newtown, Pennsylvania. In the fall of 1915 the writer received a quantity of dry-rotted roots from Wausau, Wisconsin, and from Fulton, New York. These latter roots furnished excellent material for a detailed study of the disease.

THE DISEASE

SYMPTOMS

Diseased roots show dark brown, dry lesions, which at first are small and scattered, but at length become more or less widespreading and deep-seated (figs. 1 and 2). The surface of the lesion is slightly if at all sunken, except in advanced stages of decay. It is usually smooth but may often be somewhat roughened due to the emergence of the stromata produced by the internal mycelium of the pathogene.

In general there are two types of lesions. In the first type the injury is merely superficial and is confined to a few layers of cells immediately

[1] The writer wishes to express his thanks for suggestions received in the course of this work from Professor H. H. Whetzel. Thanks are also due Mr. J. G. Koehler of Wausau, Wisconsin, for his kindness in furnishing the ginseng roots required for the investigation.

beneath the epidermis. In this case the affected tissue may be readily sloughed off by rubbing it beneath the ball of the thumb, thereby exposing to view the healthy tissue below. This character has undoubtedly given to the disease its popular name of rust. In many cases the root seems to be able to prevent the further ravages of the disease, by cutting off the tissue attacked by the formation of a centripetal cork cambium. In such cases, the decayed tissue sloughs off after a time, leaving peculiar pockings or pittings on the surface of the root. Such roots are frequently observed in gardens where the rust occurs.

FIG. 1. SURFACE VIEW OF GINSENG ROOTS ATTACKED BY RUST. (NAT. SIZE)

The second type of lesion, instead of being confined merely to the subepidermal cells, extends through the cortex, frequently involving the stele. In many cases the rot extends throughout the entire cross-section of the root, which finally separates at the point of attack, leaving a stub as shown in the root to the right in figure 1. Sometimes the crown of the root together with the bud is rotted, and in others all of the root but the bud is destroyed. In either event the plants fail to develop the following spring. On digging to ascertain the cause of the trouble very frequently

nothing of the roots is found except the remains of the epidermis. This complete disappearance of the rusted roots is due not so much to the destructiveness of the disease as to the fact that the rotted tissue is almost invariably attacked by minute white larvae which feed upon and consume the diseased roots.

HISTORY, DISTRIBUTION, AND ECONOMIC IMPORTANCE OF THE DISEASE

Save for the fact that a disease of the roots known as rust has been recognized as occurring in ginseng gardens, little is known of its history. The term rust has also been applied to a disease of ginseng seedlings caused by *Thielavia basicola* (B. et Br.) Zopf, and this same fungus at one time was also supposed to be responsible for the rust of the older roots.[2] Later evidence has failed to support this conclusion.

FIG. 2. RUSTED ROOTS IN LONGITUDINAL SECTION SHOWING THE DEEP TYPE OF LESION. (NAT. SIZE)

[2] Whetzel, H. H., and Rosenbaum, J. The diseases of ginseng and their control. U. S. Dept. Agr., Bur. Plant Ind. Bul. 250: 28–29. 1912.

It is apparent from the distribution noted above, that the disease is fairly widespread. No doubt it will later be found to occur in almost all ginseng-growing regions. In the several localities from which it has been reported it has been said to cause no little damage, growers reporting that it is now the chief problem confronting them.

ETIOLOGY

Pathogenicity

The cultures used in the following studies were isolated from rusted roots received from Wausau, Wisconsin, and from Fulton, New York. The

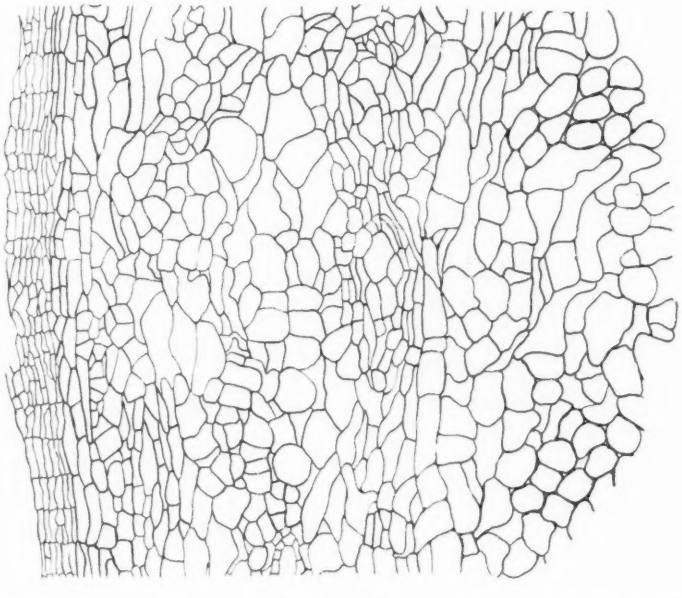


FIG. 3. CROSS-SECTION THROUGH THE HEALTHY CORTEX OF A GINSENG ROOT. (×56)

Wisconsin roots were in an advanced stage of decay so that direct plantings of diseased tissue on poured plates of hard potato agar yielded various bacteria. As abundant mycelium was seen in sections of fresh material, an attempt was made to isolate the fungus or fungi present. The method consisted in macerating a bit of the less badly diseased tissue in a drop of sterilized water in a sterilized petri dish. From the suspension thus secured dilution plates were poured, half of the plates being acidified with lactic acid so as to inhibit the growth of bacteria. The plates without acid

were so bady overrun with bacteria as to be useless. The remaining plated yielded colonies of fungi of the genera Fusarium, Penicillium, and Ramularia, the latter predominating. The organisms secured were transferres to slant tubes of agar and set aside for further study.

While the above work was in progress there was received from Fulton, New York, a shipment of roots showing the early stages of the disease. From these roots direct plantings were made on plates of hard potato agar without acid. Eighty per cent of the plantings yielded pure cultures of species of Ramularia, the remaining plantings failing to develop any fungous or bacterial growth.

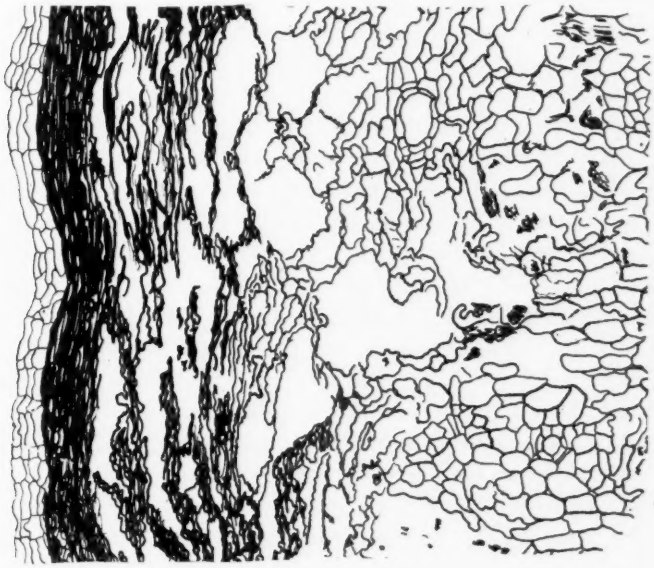


FIG. 4. CROSS-SECTION THROUGH THE DISEASED CORTEX OF A GINSENG ROOT. (× 56)

The results of the isolations indicated that the Ramularia was in all probability the causal organism. Pedigreed spore-cultures were accordingly made of the colonies secured and with these a preliminary set of inoculations was made in order to determine whether or not the organism was pathogenic.

Twelve healthy ginseng roots were surface-sterilized in a 1:1000 solution of mercuric chloride for five minutes, rinsed in sterilized water, and placed in sterilized test-tubes. These roots were injured by making a small incision in the crown and eight of them were inoculated with the species of Ramularia secured in the isolations. The remaining four roots

served as checks. The tubes were placed in a moist chamber in the laboratory. At the end of ten days it was found that four of the inoculated roots showed typical lesions of the deep type. The remaining four roots and the checks remained healthy.

While this preliminary set of inoculations was far from being conclusive it showed that a species of Ramularia was able to infect healthy roots. As there were nine separate transfers being continued at the time, a study was made of each of them in order to reduce the number to a working basis. It was found that two species had been obtained from the isolations, one appearing only in the Wausau material, later called *Ramularia destructans*, and one appearing both in the Wausau and Fulton material. The latter species was later named *Ramularia panacicola*. All further inoculation work was done with pedigreed spore cultures of these two species.

In the absence of pathogenes, ginseng roots are able to remain in the soil in a normal and healthy condition throughout the dormant season. It was therefore thought advisable to conduct further inoculation work with roots which had not been surface sterilized, and which were allowed to remain in the soil after inoculation. Accordingly, on January 3, 1916, thirty-two roots were injured as described in the preceding experiment, twelve were inoculated with *R. destructans* and twelve with *R. panacicola*, the remaining eight serving as checks. All roots were then wrapped about the crown with absorbent cotton, to prevent soil entering the injuries, and then placed in a box in clean sand and allowed to remain out-of-doors until April 12, when they were removed and examined.

It was found that the checks had remained in perfect condition. One hundred per cent infection was obtained with both species of Ramularia, the deep type of rot resulting in all cases, as might be expected from the fact that the roots were previously injured. Some of the roots were affected only at the crown, while in other cases the rot had spread and involved one-half to two-thirds of the entire root.

Plantings from the diseased tissue of these roots yielded pure cultures of each species of Ramularia, twenty-nine out of thirty-two plantings yielding colonies. Here then was conclusive evidence of the pathogenicity of the fungi, and also a corroboration of a previous impression that the *disease spread* during the dormant season.

Further inoculations were made on June 5, 1916, when two sets of fourteen roots each were inoculated respectively in the above manner with one of the two species. These roots were then placed outside in soil. Ten roots were used as checks. Upon examination on June 20, it was found that the checks had remained healthy while twelve of the fourteen roots inoculated with *R. panacicola* showed typical lesions 1.5 to 2.5 cm. in

diameter. Of the roots inoculated with *R. destructans* only seven showed similar signs of infection.

Pathological Histology

A cross-section through the cortical tissue of a ginseng root is shown in figure 3. Here it is seen that the cortex is made up of parenchymatous cells with occasional scattered schizogenously formed resinducts which in the healthy root contain a kind of resin. The parenchyma cells of the cortex as well as those of the stele are closely packed with starch at the end of the growing season.

In figure 4 there is shown a cross-section through the cortex of a diseased root. It is seen that the cells of the periderm are not attacked by the fungus. The cells immediately beneath this layer are most affected, being almost completely disorganized by the abundant hyphae which traverse them intracellularly in every direction. In figure 5 is shown a more highly magnified bit of tissue in an advanced stage of decay.

The cell walls appear to be partially digested, but the middle lamella is little affected, since diseased tissue when examined under the microscope does not show maceration such as that which takes place in roots attacked by the White Rot (*Sclerotinia libertiana* Fckl.) or Soft Rot (*Phytophthora cactorum* (Cohn et Leb.)) organisms. At first the starch does not appear to be attacked but later almost entirely disappears. In the most advanced stages of the disease all semblance of tissue organization is lost. A cross-section through the root at this time shows only portions of the cell walls intermingled with the mass of mycelium. Large internal cavities often appear (fig. 4) but these do not bring about such general shrinkage of the tissue as to make the lesion a sunken one.

In the superficial type of lesion the hyphae are restricted to a few tiers of cells immediately beneath the periderm. The mycelium gathers in dense masses in these cells but seemingly is unable to penetrate farther into the interior of the root, often being cut off from the healthy tissue by an inner periderm layer.

In both types there is a marked massing of the mycelium immediately beneath the periderm. The hyphae then pass at various points into the cells of the periderm. After they have gained entrance to these cells they form a pseudo-parenchyma and by continued growth and expansion finally rupture the cell walls. The mycelium in the form of pseudoparenchyma then protrudes through the periderm and spreads out upon its surface. The stromata (fig. 6), which are formed in this manner later bear upon their surface many simple to sub-simple conidiophores. In longitudinal section the stromata have the general appearance of a sheaf of wheat.

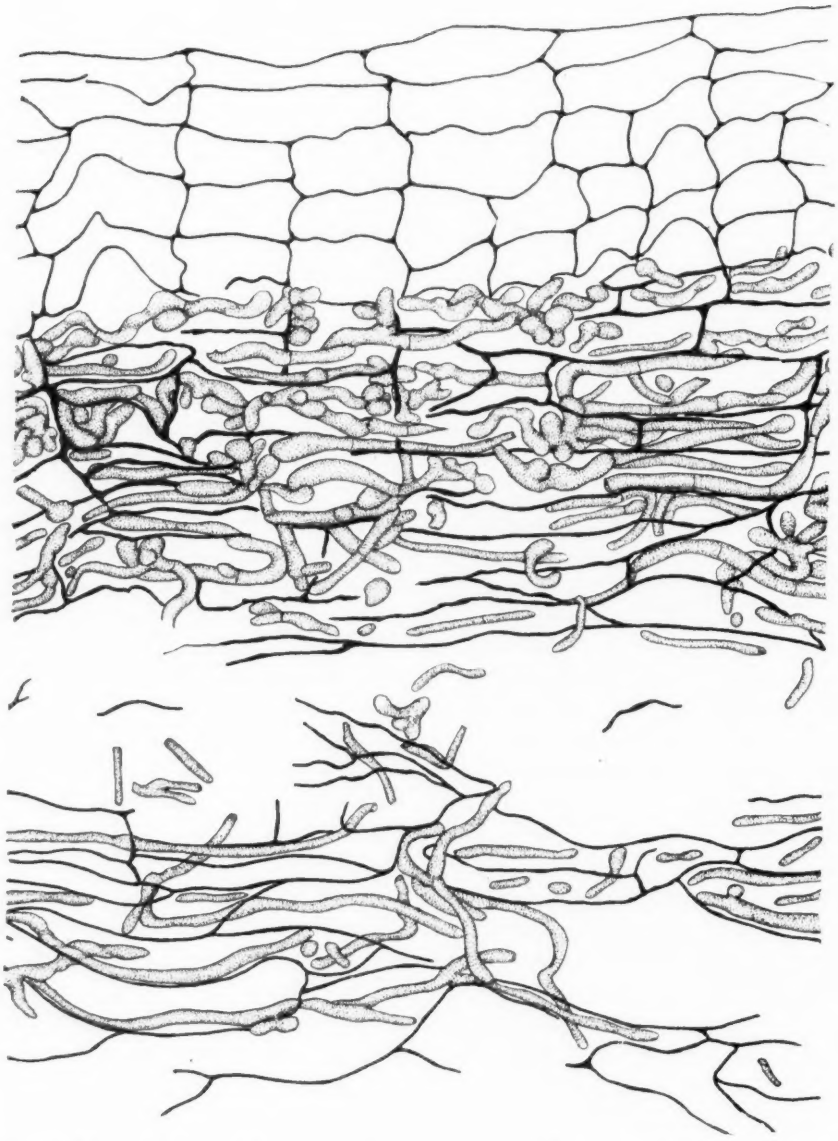


FIG. 5. MORE HIGHLY MAGNIFIED PORTION OF THE DISEASED CORTEX SHOWING MYCELIUM IN THE HOST CELLS. (× 200)

They are brown or reddish-brown in color and give to the roots which bear them a characteristic rusted appearance.

It was thought that a perfect stage might be associated with these stromata, but though a large number of sections were examined, no evidence of such a stage has been found. As both the species of Ramularia in culture produced chlamydospores abundantly, Wollenweber's view that a perfect stage is not associated with chlamydospores[3] is corroborated.

IDENTITY OF THE PATHOGENES

The fungi isolated from rusted roots and later proved to be pathogenic are characterized by having cylindrical, apedicillate, septate, hyaline conidia which are produced at the apices of simple or verticillately branched

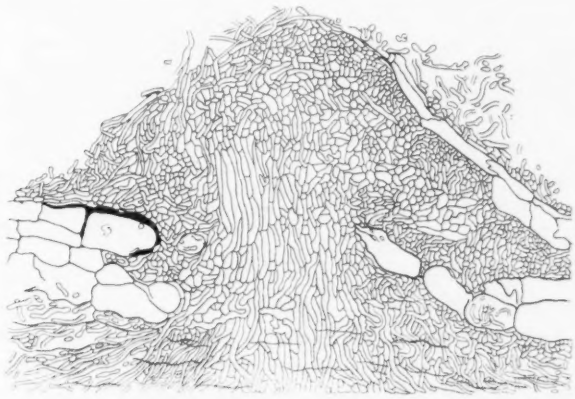


FIG. 6. LONGITUDINAL SECTION THROUGH A STROMA. (× 237)

conidiophores. These conidiophores are grouped in sporodochia (on boiled rice and raspberry cane plugs), or arise from a well-defined, chestnut-brown (R)[4] stroma. Microconidia are absent. In culture, intercalary, dark brown chlamydospores produced in chains or grouped in knotted masses are formed in great abundance. From these characters the fungi are to be placed in the genus Ramularia (Unger) Fries[5] as revised by Wollenweber.[3]

[3] Wollenweber, H. W. Ramularia, Mycosphaerella, Nectria, Calonectria. Eine morphologische pathologische studie zur abgrenzung von pilzgruppen mit cylindrischen und sichelformigen konidienformen. Phytopath. **3:** 208–209. 1913.

[4] The symbol (R) is throughout used to denote the fact that the color nomenclature is that of Ridgway. Ridgway, Robert. Color standards and color nomenclature. 1912.

[5] Fries, E. M. Summa vegetabilium Scandinaviae. p. 495. 1833.

In attempting to identify these species of Ramularia one is forcibly impressed with Wollenweber's statement regarding this and related genera. He says, "Sie sind Komposthaufen, deren Hohe von der Sammellust der Forscher, nicht aber von dem hohen Stande der Forschung zeugt."[6]

The majority of Ramularias which have been described cause leaf-spots on a wide variety of hosts, all that seems to have been necessary for the foundation of a new species being the discovery of a Ramularia on a host not hitherto reported. Almost no cross-inoculation work has been done, nor has pure culture work been reported save for a very few species. The specific descriptions in the literature are mostly based on a record of the host, the character and size of the leaf-spots produced, and measurements of the conidia. As there are over three hundred recorded species in the genus it is almost if not absolutely impossible to identify species occurring on a hitherto unrecorded host. Added to this is the fact that no Ramularias have been described as parasitic on the roots of any host, though Wollenweber and Sherbakoff[7] report certain species as present in rotted potato tubers. It would appear that our species have not been described heretofore and the descriptions are therefore appended.

CULTURAL CHARACTERS OF THE PATHOGENES

In culture on poured plates of lima bean and potato agar *R. destructans* shows a scanty and somewhat finely zonated aerial growth as compared with that of *R. panacicola*. As the cultures grow older the mycelium in the former species becomes more or less merged with that of the substratum, giving the surface a somewhat mealy appearance, which is more marked in the case of the bean agar culture than in that of the potato agar culture. The color of the stroma is throughout deeper on the latter medium and is a chestnut-brown (R). No differences are to be noted between the two species when grown on raspberry cane plugs. When grown in flasks on boiled rice, *R. destructans* produces no color in the substratum while *R. panacicola* colors it a pale, diffuse, Nile-blue (R), which appears about four days after sowing the culture and disappears about a month later. Both species produce in the agar media a large number of small, brown, sclerotium-like bodies, 0.5 to 2 mm. in diameter. *R. panacicola* differs most strikingly in culture from *R. destructans* in its much more copious, cinnamon-brown (R) aerial mycelium.

[6] Wollenweber, l. c. p. 198.

[7] Sherbakoff, C. D. Fusaria of potatoes. Cornell Univ. Agr. Exp. Sta. Mem. **6**: 1–270. Figs. 1–50. Pls. I–VII. 1915.

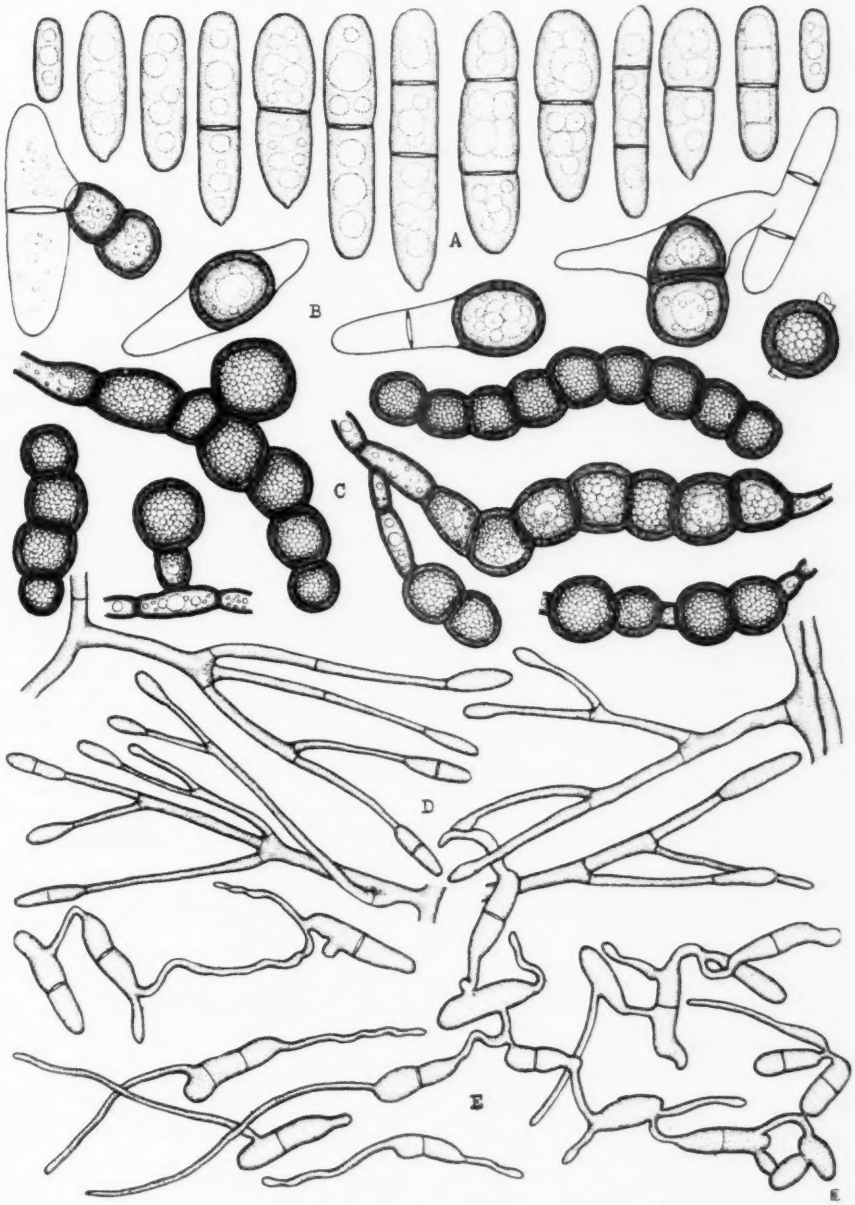


FIG. 7. *Ramularia destructans.*

A, Conidia (× 1333); *B*. Conidia producing endogenous chlamydospores (× 1333); *C*, Chlamydospores (×1333); *D*, Conidiophores (× 333); *E*, Germinating conidia anastomosing and forming chains (× 333).

COMPARATIVE MORPHOLOGY OF THE PATHOGENES

In studying the morphology of these two fungi, pedigreed spore-cultures in tubes were carried on standardized (+12) lima bean and potato agar, boiled rice, and raspberry cane plugs. Plate cultures were made and examined for differences in macroscopic growth.

No differences are to be observed between the mycelia of the two fungi. The conidiophores of *R. destructans* (fig. 7, *D*) as a rule appear to be less branched and simpler than those of *R. panacicola* (fig. 8, *C*). The chlamydospores of both are approximately equal in size, color and manner of production (fig. 7, *C*, and fig. 8, *B*). Measurements were made of one thousand chlamydospores of each species from potato agar cultures. The closeness of their agreement can be seen from the following table.

TABLE 1

Measurements of chlamydospores from potato agar

DIAMETER IN MICRONS	NUMBER OF R. DESTRUCTANS	NUMBER OF R. PANACICOLA
5.25	10	7
7.00	83	71
8.75	162	131
10.50	211	190
12.25	281	297
14.00	196	182
15.75	49	92
17.50	8	30
Total	1,000	1,000

On germination of the conidia of *R. destructans*, the germ tubes, appear to anastomose more freely (fig. 7, *E*) than do those of *R. panacicola* (fig. 8, *D*). It is in the morphology of the conidia that the two species differ most markedly. The conidia of *R. destructans* are much larger in diameter than those of *R. panacicola*. The majority of them are one-septate in the former, while those of the latter species are mostly non-septate. The marked difference with regard to septation is shown in the following summary of the eight thousand conidia examined:

DESCRIPTIONS OF THE SPECIES

	R. destructans	*R. panacicola*
0-septate	8.00	69.00
1-septate	85.00	31.00
2-septate	6.00	
3-septate	1.00	

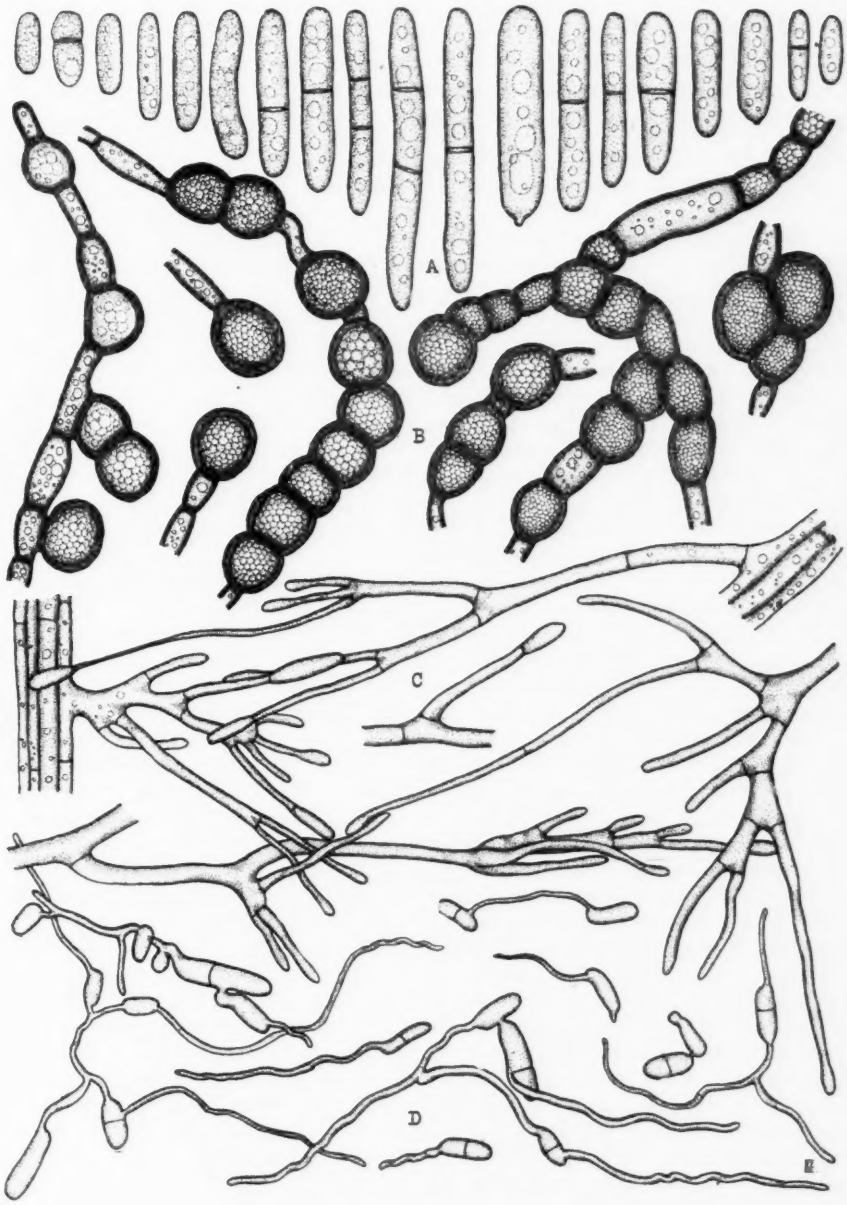


FIG. 8. *Ramularia panacicola*

A, Conidia (× 1333); *B*, Chlamydospores (× 1333); *C*, Conidiophores (× 333); *D*, germinating conidia anastomosing and forming chains (× 333).

The conidia of the first species also not infrequently produce chlamydospores endogenously, while this method of chlamydospore formation was not observed in the second species (fig. 7, *A* and *B*, fig. 8, *A*). The conidia of the former species measure 3.5–8.0 x 9.0–32.4μ, three thousand of the four thousand spores measured falling between 5.5–6.5 x 10.8–32.4μ. The conidia of *R. panacicola* measure 2.5–7.2 x 5.5–34.2μ, three thousand of them measuring 3.5–4.5 x 5.4–29μ.

Ramularia destructans n. sp. (fig. 7, *A*, *B*, *C*, *D*, *E*).

Conidia hyaline, cylindrical to ovate-cylindrical or ellipsoidal; frequently papillate; 0-3-septate (85 per cent 1-septate), often constricted slightly at the septa; (4000) 3.2–8.1 x 9.0–32.4 microns (common measurement (3000) 5.5–6.5 x 10.8–32.4 microns); conidia often producing chlamydospores endogenously; conidia borne at the tips of simple to sub-simple conidiosphores which may be scattered or in sporodochia borne on the chestnut-brown (R) stromata; aerial mycelium (in agar culture) at first white, soon becoming cinnamon-brown (R), sparse, later merging with the substratum and giving the surface a mealy appearance; irregular, small, dark brown sclerotium-like bodies developed in the substratum, 0.5–2.0 mm. in diameter; chlamydospores abundant, mostly intercalary, in chains or knotted masses, darker than chestnut-brown (R) (1000); 5.25–17.5 microns in diameter, mostly 8.75–14.0 microns. Boiled rice substratum not diffusely colored.

Hab. in living roots of *Panax quinquefolium* L. Wausau Wisconsin.

Ramularia destructans nov. sp. (fig. 7, *A*, *B*, *C*, *D*, *E*).

Conidiis hyalinis, cylindraceis vel ovatis-cylindraceis vel ellipsoideis; saepius papillatis; 0.3-septatis (85 per centum 1-septatis), saepius parce constrictis ad septatis; (4000) 3.2–8.1 x 9.0–32.4 μ (plerumque (3000) 5.5–6.5 x 10.8–32.4 μ); conidiis saepius chlamydosporiis endogeniter productis; conidiophoribus simplicibus vel sub-simplicibus vel verticillatis ramosis, dispersis vel in sporodochiis ex chestnut-brown (R) stromatibus; aerio mycelio (in agar culturis) primo albo, deinde cinnamon-brown (R) sparsis, demum cum substrato mersis et superficies granulosus conspectus datus; irregularibus, parvis, atro-brunnei, sclerotiis in culturis productis, 0.5–2.0 mm. in diam.; chlamydosporiis pleniter, plerumque intercalariis, concatenis vel granulosis, ateriore chestnut-brown (R); (1000) 5.25 x 17.5 μ in diam. plerumque 8.75–14.0 μ. Oryza substrato non diffuso coloratis.

Hab. in rhizibus vivis Panacis quinquefolii L, Wausau, Wis. Am. bor.

Ramularia panacicola n. sp. (fig. 8, *A*, *B*, *C*, *D*).

Conidia mostly hyaline but frequently with a tinge of brown when viewed under the microscope; fusiform or long-cylindrical to ellipsoidal, infrequently papillate; 0–1-septate, (69 per cent 0-septate), not producing chlamydospores endogenously nor commonly constricted at the septa; (4000) 2.5–7.2 x 5.5–34.2 microns (common measurement (3000) 3.5–4.5 x 5.4–29.0 microns); conidia borne at the tips of sub-simple or verticillately branched conidiophores which are scattered or grouped in sporodochia; stromata darker than chestnut-brown (R); aerial mycelium at first white (in agar culture) soon changing to cinnamon-brown (R), abundant, not often merging with the substratum; small, sclerotium-like bodies produced in culture, dark brown, 0.5–2.0 mm. in diameter. Chlamydospores abundant, mostly intercalary, in chains or knotted masses, darker than chestnut-brown (R) (1000); 5.25–17.5 microns in diameter, mostly 8.75–14.0 microns. Boiled rice colored a diffuse, pale Nile blue (R).

Hab. in living roots of *Panax quinquefolium* L. Wausau, Wis. Fulton, N. Y.

Ramularia panacicola nov. sp. (fig. 8, *A*, *B*, *C*, *D*).

Conidiis plerumque hyalinis sed sub microscopis saepius leviter brunneis coloratis; fusoideis vel longo-cylindraceis vel ellipsoideis infrequenter papillatis; 0.1-septatis (69 per centum 0-septatis). chlamydosporiis endogeniter nec productis non fere constrictis ad septatis; (4000) 2.5–7.2 x 5.5–34.2 μ (plerumque (3000) 3.5–4.5 x 5.4–29.0 μ); conidiis ad apicibus sub-simplicibus vel verticillatis ramosis conidiophoriis abstrictis, conidiophoriis dispersis vel in sporodochiis; stromatibus ateriore-chestnut-brown (R); aerio mycelio primo albo (in agar culturis), copiosis, mox cinnamon brown (R) non saepius cum substrato mersis; parvis, atro-brunneis sclerotiis in agar culturis productis; chlamydosporiis copiosis, plerumque intercalaris, concatenis vel granulosis, ateriore-chestnut-brown (R); (1000) 5.25–17.5 μ in diam., plerumque 8.75–14.0 μ. Oryza substrato diffuso, pale Nile blue (R).

Hab. in rhizibus vivis Panacis quinquefolii L. Wausau, Wis., Fulton, N. Y. Am. bor.

DEPARTMENT OF PLANT PATHOLOGY,
CORNELL UNIVERSITY

THE ORIGIN AND SPREAD OF TOMATO FRUIT ROTS IN TRANSIT[1]

J. ROSENBAUM

Inquiries and complaints received from growers and commission men showed the necessity of determining the origin of the various tomato rots and the ability of these to spread in transit. The needs and purposes of such a study are evident and their relations to phytopathological investigations have been recently summarized by Shear.[2]

The work here reported was done with Florida grown winter tomatoes at Miami. The shipments were made to New York City throughout the past season at intervals of a week or less and in accordance with the commercial practices followed in Florida. The tomatoes were picked green and allowed to ripen in transit or after reaching the market. Most of the shipments were made from the latter part of January until the middle of May. The tomatoes were shipped either in ventilated cars or refrigerator cars which were not iced. The cars were in transit from seven to eleven days.

It was observed, after making a few preliminary shipments, that little conclusive data would be obtained in regard to the spread of the various diseases from the examination of the commercial shipments alone, on account of the fact that the epidemic form of the various troubles did not exist in the same field. The chance of including a diseased tomato was, therefore, small. In order to remedy this condition and to obtain data on the spread of the different diseases generally found at the terminal markets, it was decided to artificially inoculate two tomatoes in each basket just previous to packing, mark such fruit and note the condition of this fruit as well as the healthy adjacent fruit in the basket upon arrival at the markets.

The commercial method of packing the fruit is in baskets. Six baskets are packed to a crate. One inoculated fruit was placed in the center of each layer of the basket.

[1] The following men from the Bureau of Plant Industry and Bureau of Markets have aided in the examination upon arrival of one or more of the shipments: Mr. G. H. Godfrey, Drs. George K. K. Link, N. E. Stevens, V. B. Stewart, Mr. C. S. Pomeroy and Mr. S. L. VanOrman.

[2] Shear, C. L. Pathological Aspects of the Federal Fruit and Vegetable Inspection Service. Phytopath. **8:** 155–160. 1918.

The following diseases have been found to occur on the tomato fruit upon arrival at the markets as well as in the fields on the East Coast of Florida.

1. Nail Head Spot (*Macrosporium solani*).
2. Black Spot (*Phoma destructiva*).
3. Anthracnose (*Colletotrichum phomoides*).
4. Buckeye Rot (*Phytophthora terrestria*).
5. Soil Rot (*Rhizoctonia* sp.).
6. White Rot (*Sclerotium Rolfsii*).
7. Leak (*Rhizopus* sp.).

During the season seventeen special shipments involving seventy-five crates were made. In addition, the writer had an opportunity to examine and obtain data on a larger number of shipments made for other purposes by the Bureau of Markets. The results of all the shipments were uniform as regards the origin and spread of the diseases in transit.

The universal practice followed commercially in Florida is to wrap each tomato in paper. In order to determine whether wrapping the fruit has any appreci le effect upon the rate of spread of the disease, some preliminary trials were made in shipments where the fruit was not wrapped. Aside from the fact that the unwrapped fruit arrived in a looser condition and, therefore considerably bruised, no great differences were found from the results obtained with the wrapped fruit.

With the possible exception of Phoma rot and Leak (Rhizopus) transit conditions have not been found to be the cause of the origin of the diseases observed upon arrival at the market. The known factors favoring the appearance of these two diseases are bruises or injuries to the skin, overripening, and in the case of the Phoma rot, the presence of the disease in the field.

The origin of the other diseases mentioned is in all cases a result of field infection just previous to packing or the spread of the fungus after packing from one or more diseased fruit included in the pack.

On account of the uniformity of the results obtained in all the experimental shipments, the detailed data of only the last four shipments are presented in Table I. The counts were made by basket. In every case twenty-four tomatoes were packed to the basket.

Examination of this table shows that some of the fungi are able to grow through the wrapper and infect healthy adjacent fruit. Others are able to grow through the wrapper and infect adjacent fruit but such infection can take place only through the stem end or through some bruise in the skin. The remainder are unable to penetrate the tomato wrapper.

In the case of the fungi which are able to grow through the tomato wrapper very often practically every tomato in the basket may show the

TABLE 1

Spread of rots in tomatoes in transit

INOCULATED	DATE SHIPPED	DATE EXAMINED	CONDITION OF PACK	CONDITION OF TWO INOCULATED FRUIT	NUMBER ADJACENT FRUIT INFECTED	REMARKS
Phytophthora.....	April 29	May 9	Not wrapped	2[3]	5 (4 red, 1 green)	Infection through unbroken surface
	April 29	May 9	Wrapped	2−	0	
	May 2	May 10	Not wrapped	2+	5 (1 red, 2 pink, 1 green)	Infection through unbroken surface.
	May 2	May 10	Wrapped	2+	4 (2 red, 2 pink)	Infection at stem end and through unbroken surface
	May 2	May 10	Wrapped	2+	6	Infection as above
	May 5	May 14	Not wrapped	2+	9 (5 red, 3 turning, 1 green)	Infection as above
	May 5	May 14	Wrapped	2+	2 red	Infection as above
	May 5	May 14	Wrapped	2+	4 (2 red, 1 pink, 1 turning)	Infection as above
Sclerotium	April 22	April 29	Not wrapped	2+	5	All affected fruit covered with mycelium and sclerotia of fungus
	April 22	April 29	Wrapped	2+	4	As above
	April 22	April 29	Wrapped	2+	11	Mycelium and sclerotia formed on outside and inside of wrapper
	April 29	May 9	Not wrapped	2+	2	Infection through stem end
	April 29	May 9	Wrapped	2+	5(all red)	Mycelium and sclerotia found on wrappers of eleven fruit

[3] + indicates positive infection; − indicates failure to infect.

Sclerotium.....	May 2	May 9	Not wrapped	2+	10 (9 red, 1 turning)	Mycelium and sclerotia of fungus covered entire basket
	May 2	May 9	Wrapped	2+	15	Wrappers of 21 tomatoes covered with mycelium and sclerotia
	May 2	May 9	Wrapped	2+	11	Wrappers of 17 tomatoes covered with mycelium and sclerotia
	May 5	May 12	Wrapped	2+	3 (1 green, 2 pink)	Fungus found on wrappers of 8 fruit; stem end infection
	May 5	May 12	Not wrapped	2+	4 (2 red, 1 turning, 1 green)	Twelve adjacent fruit with fungus on surface
	May	May 12	Wrapped	2+	5 (3 red, 2 pink)	13 fruit as above
Colletotrichum....	April 22	April 29	Not wrapped	2+	0	Pink ooze of spores of fungus on inoculated fruit
	April 22	April 29	Wrapped	2+	0	Pink ooze of spores of fungus on inoculated fruit
	April 22	April 29	Wrapped	2+	0	As above
	April 29	May 9	Not wrapped	2−	0	
	April 29	May 9	Wrapped	2+	0	Inoculated fruit covered with pink ooze of spores. No signs of fungus on outside of wrapper
	May 2	May 10	Not wrapped	2−	0	
	May 2	May 10	Wrapped	2+	0	As for shipment made April 29
	May 2	May 10	Wrapped	1+, 1−	0	Spore ooze found on inside of wrapper
	May 5	May 13	Not wrapped	1+, 1−	0	
	May 5	May 13	Wrapped	2+	0	
	May 5	May 13	Wrapped	2+	0	Pink spore ooze found on inside of wrapper of inoculated fruit

TABLE 1—*Continued*

INOCULATED	DATE SHIPPED	DATE EXAMINED	CONDITION OF PACK	CONDITION OF TWO INOCULATED FRUIT	NUMBER ADJACENT FRUIT INFECTED	REMARKS
	April 29	May 9	Not wrapped	2+	0	An abundance of spores formed on inoculated fruit
	April 29	May 9	Wrapped	2+	0	As above. The fungus does not grow through paper
Phoma	May 2	May 10	Not wrapped	2+	0	As above
	May 2	May 10	Wrapped	2+	0	As above
	May 2	May 10	Wrapped	2+	0	As above
	May 5	May 14	Wrapped	2+	0	As above
	May 5	May 14	Not wrapped	2+	0	As above
	May 5	May 14	Wrapped	2+	0	As above
	April 22	April 29	Not wrapped	2+	2	Infection at stem end
	April 22	April 29	Wrapped	2+	1	As above
	April 22	April 29	Wrapped	2+	7	Infection at stem end or through wound
	April 29	May 9	Not wrapped	2+	2 { 1 red, 1 green	Infection through stem end
	April 29	May 9	Wrapped	2+	2 turning	As above
Rhizoctonia	May 2	May 9	Not wrapped	2+	5	Infection through stem end or bruise. Two other fruit with fungus on surface but no penetration
	May 2	May 9	Wrapped	2+	2	Growth of fungus extended to 5 other fruit but not penetrated
	May 2	May 9	Wrapped	2+	9	Wrappers of 16 tomatoes covered with mycelium and sclerotia

Rhizoctonia	May 5	May 13	Not wrapped	2+	2 (1 red, 1 green)	Fungus entered through stem end
	May 5	May 13	Wrapped	2+	5 (3 red, 2 green)	Sclerotia and mycelium found on wrappers of seven fruit
	May 5	May 13	Wrapped	2+	3 (2 red, 1 green)	Fungus found on wrappers of twelve fruit
No inoculation	April 22	April 29	Not wrapped		0	Two over ripe fruit affected with Rhizopus
	April 22	April 29	Wrapped		0	
	April 29	May 9	Not wrapped		0	
	April 29	May 9	Wrapped		0	Five ripe fruit affected with Rhizopus soft rot
	May 2	May 9	Not wrapped		0	
	May 2	May 9	Wrapped		0	
	May 5	May 14	Wrapped		0	
	May 5	May 14	Not wrapped		0	
	May 5	May 14	Wrapped		0	

growth of the fungus either on the inside or outside of the wrapper but only a portion of these show infection.

The rate of spread as indicated by the number of infected fruit will naturally vary with temperature in the car, maturity and ripeness of the fruit and other conditions. It was found that under the same transit conditions, some of the fungi are able to spread faster than others. *Sclerotium Rolfsii* and *Rhizopus* sp. are examples of those which spread with great rapidity while Rhizoctonia under the same conditions is a slow grower.

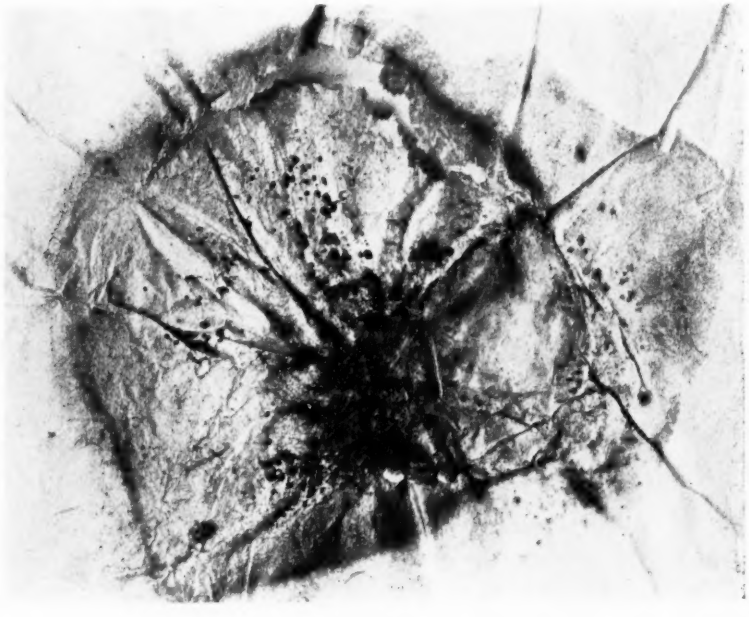


FIG. 1. PHOTOGRAPH OF TOMATO WRAPPER SHOWING GROWTH OF MYCELIUM AND SCLEROTIA OF RHIZOCTONIA FUNGUS

Mycelium and sclerotia found on both sides of wrapper.

In some of the fungi, there may be produced within the wrapper an abundance of spores unaccompanied by an appreciable growth of new mycelium. In such cases it is rare to find the fungus penetrating the wrapper. Examination of Table I shows that this frequently takes place in the case of Phoma and Colletotrichum.

For the sake of convenience, from the data given, the tomato rots discussed here may be divided into three groups based on their ability to spread to healthy adjacent fruit.

Group I includes those which can spread to *healthy uninjured* fruit; i.e., those in which the causal organism can gain an entrance through any portion of the fruit. Buckeye Rot (*Phytophthora terrestria*) is the only one found in this group. This Phytophthora has been found to grow through the wrapper and infect the apparently healthy uninjured surface of both green and ripe tomatoes.

Group II includes these tomato rots where the causal organism can spread but can gain entrance and infect adjacent fruit only *through the stem end* or *through some injury* in the skin. In this group are included Soil Rot (*Rhizoctonia* sp.), White Rot (*Sclerotium Rolfsii*) and Leak (*Rhizopus* sp.).

Soil Rot has been found to spread to ripe and green fruit. The Rhizoctonia fungus grows readily on the tomato wrapper with an abundant production of the sclerotia of the fungus. Figure 1 is a photograph of a tomato wrapper showing the mycelium and sclerotia of Rhizoctonia on the tomato wrapper. The basket from which this was taken contained at the time it was packed two freshly inoculated fruit. Upon arrival at the market eight days later five additional fruit were infected, the wrappers of each of these showing the mycelium and sclerotia of the fungus.

White Rot (*Sclerotium Rolfsii*) was found especially abundant in cars shipped from Cuba, on both ripe and green fruit. The fungus is able to grow with great rapidity through several thicknesses of tomato wrappers. Long white strands or mats of mycelium are produced, followed by an abundant production of the sclerotia both on the inside and outside of the wrapper, as shown in plate IV, figures A and B. Infection in transit takes place only through the stem end or through a bruise in the skin.

Leak (*Rhizopus* sp.) occurs only on ripe or overripe fruit which have a break in the skin. On such fruit it has been found to grow with great rapidity and to spread to similar adjacent fruit. It has also been found in the field causing a water-soaked lesion on ripe tomatoes. Its effect upon fruit in transit is to cause its collapse, followed by growth of the fungus on the wrappers, baskets, and sides of the crate. So far as known it has not been previously reported as causing a rot of tomatoes in the United States. Plate IV, figure C, shows a single fruit with the fruiting bodies of the fungus.

Group III includes those tomato rots which are not able to spread in transit. Nailhead Spot (*Macrosporium solani*), Black Spot (*Phoma destructiva*) and Anthracnose (*Colletotrichum phomoides*) belong to this group.

The evidence bearing on the origin and spread of the Nailhead Spot (*Macrosporium solani*) on tomatoes will be presented in a separate paper. Suffice it to say that the results so far obtained tend to show that this disease does not ordinarily originate in transit and does not spread to healthy adjacent fruit.

The fungi causing the last two diseases mentioned produce an abundance of spores within the wrappers and on the surface of the fruit, but they are apparently unable to grow through the tomato wrappers.

The Phoma disease is generally found at the stem end, in growth cracks occurring at the stem end, or wherever the skin of the tomato is broken. Finger nail punctures, scratches on the surface of the fruit due to sand in the field boxes, insect punctures, and other mechanical injuries are factors in the severity and appearance of this disease in transit.

It has also been found as a secondary rot following nailhead spot. Entrance in this case is made through the crack in the fruit associated with old nailhead spots.

SUMMARY

1. With the possible exception of Phoma rot and "Leak" (*Rhizopus* sp.) the tomato fruit rots found upon arrival of the car do not originate in transit. They originate in the field and spread in transit from one or more infected fruit included in the pack.

2. Transit or other conditions favoring the development of Phoma rot and "Leak" have not been determined. Overripeness of the fruit and bruises or other injuries favor their appearance.

3. Based on their ability to spread in transit from one or more infected fruit, the tomato fruit rots may be divided into three groups as follows:

Group I includes those rots where the causal fungus can spread and infect adjacent uninjured fruit. Buckeye Rot (*Phytophthora terrestria*) represents this group.

Group II includes rots where the causal organism can spread but infects fruit only through the stem end or through some break in the skin of the tomato. In this group are included Soil Rot (*Rhizoctonia* sp.), White Rot (*Sclerotium Rolfsii*) and "Leak" (*Rhizopus* sp.).

Group III includes those diseases where the causal fungus is unable to grow through the tomato wrappers and infect healthy adjacent fruit. Representatives of this group are Nail Head Spot (*Macrosporium solani*), Black Spot (*Phoma destructiva*) and Anthracnose (*Colletotrichum phomoides*).

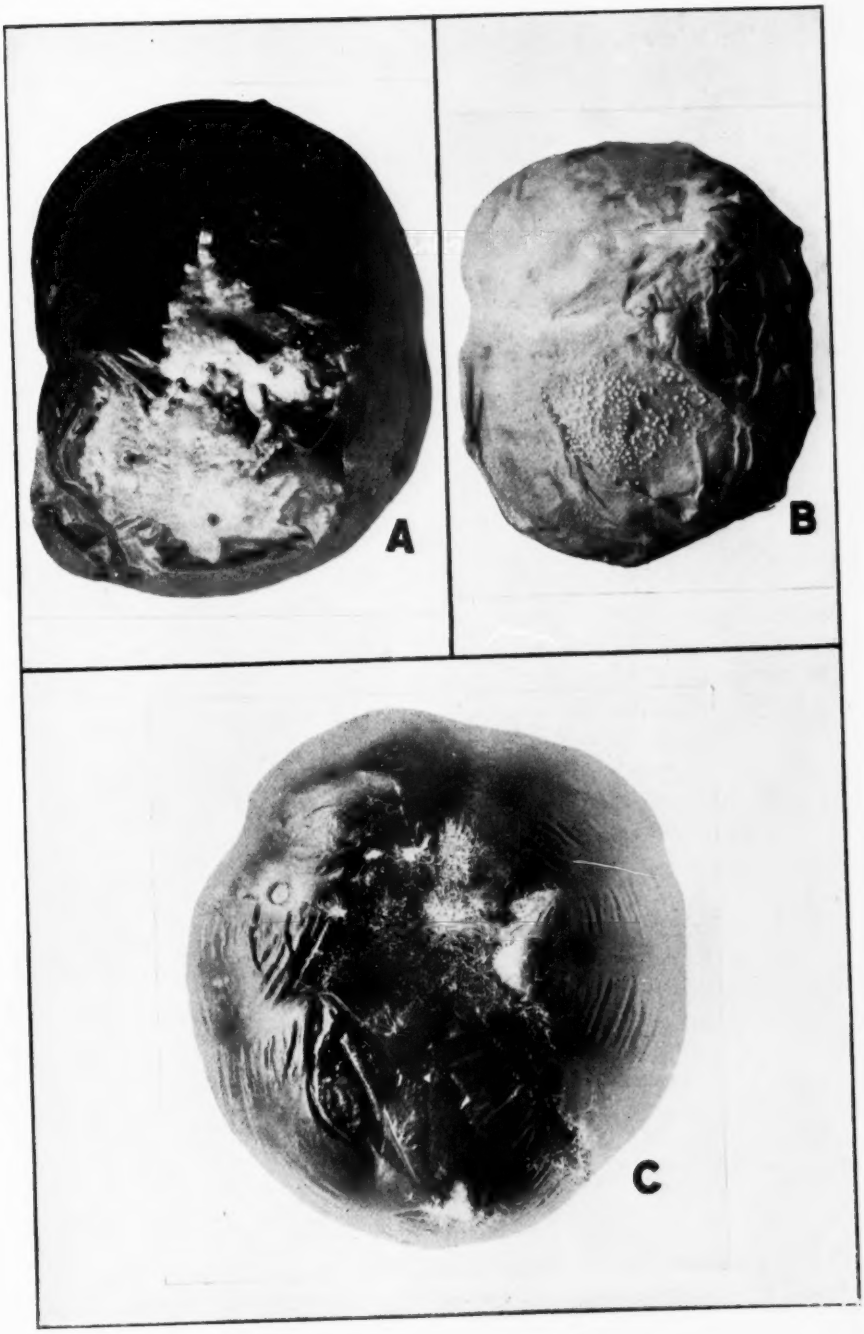
BUREAU OF PLANT INDUSTRY
WASHINGTON, D. C.

PLATE IV

Fig. A. *Sclerotium Rolfsii* on tomato fruit after the wrapper has been removed.

Fig. B. *Sclerotium Rolfsii* on tomato fruit showing immature sclerotia formed on outside of wrapper.

Fig. C. *Rhizopus* sp. attacking a ripe fruit at the stem end and through cracks



ROSENBAUM: TOMATO ROTS IN TRANSIT

BRIEFER ARTICLES

NOTES ON SOME METHODS AND TERMS EMPLOYED IN STUDYING THE UREDINALES

H. R. Rosen

Having had the privilege for a time in assisting at studies for the preparation of the manuscript of the *Uredinales* for the *North American Flora* at the Botanical Laboratory of the Indiana Experiment Station, the writer has become familiar with the methods and terminological usage which have been developed under the direction of Dr. J. C. Arthur. Believing that a brief statement regarding some of these methods and terms will be helpful to users of the part of the *North American Flora* pertaining to the rusts, and acting upon a suggestion by Dr. Arthur, the following notes are presented.

It may be worth while first to point out a few differences between descriptions of rust species developed by Dr. Arthur and his assistants and those presented by other uredinologists. The difference is especially striking if the rust literature dating previous to the time of publication of the *North American Flora* is compared with this publication. Among the important diagnostic characters which Dr. Arthur and his assistants have elaborated are (1) *spore-wall color*, in distinction to spore color used by many uredinologists and which may refer to the color of cell contents, a rather ephemeral feature, or to wall and cell contents or to the wall alone, which is rather indefinite; (2) measurements of *radial* sections of peridial cells and the distinction between color, width and markings of the outer and inner walls of such cells; (3) *spore-wall markings* with concise and distinctive terms to enable one to differentiate between the various types of markings, and (4) *pores* within the various spore-walls, features which, although difficult to discern at times, are almost invariably so fixed in number, arrangement, etc., for different species that they frequently will help in identifying specimens when other differential characters are wanting.

THE CELL-WALL AND ITS MARKINGS

The cell-wall of the various spore forms presents several important diagnostic characters such as color, thickness, type of markings, and other features.

In distinguishing wall color the workers in this laboratory have adopted a simple system which has been found to be very useful in working with rust spores. Nine different colors, or groups of colors, are recognized, namely, colorless, light-yellow, yellow, orange-yellow, golden-brown, cinnamon-brown, chestnut-brown, chocolate-brown, and blackish, and any rust spore may be quite readily placed in one of these divisions. Like any other scheme for interpreting or matching colors this leaves a wide latitude for individual interpretation, but it works very satisfactorily, since a comparison of descriptions by different observers has usually shown a close agreement.

When the wall is noticeably colored it is usually an easy matter to measure its thickness. Difficulty arises when the wall is either faintly or too densely colored. In the former case some cell-wall stain is used, the important consideration being to use a stain which will differentiate the wall from the spore contents. For this purpose chloral-hydrate-iodine is frequently utilized. When the wall is densely colored, so that no clear optical section is visible, lactic acid is used as a clearing agent, a drop of the acid being placed at the edge of the cover-glass of an ordinary water mount and the slide then heated. In some species of rusts, especially those having a waxy spore-wall, wall thickness cannot be ascertained in water mounts, since such walls usually gelatinize and swell considerably in water. In such cases alcohol is used as the dispersion medium. Sometimes the rust sorus is so waxy that it is very difficult to scrape whole spores from it. It may be worth while to cite the case of a rust, *Sphenospora pallida*, in which the telial sori are so waxy and so unlike any ordinary, pulverulent, rust sori that after making several water mounts and finding no spores the writer was about to conclude that it was not a rust. It was only after boiling some of the sori in a dilute solution of potassium-hydroxide that the true nature of the fungus was established.

Surface markings are usually distinctive and are ordinarily rather easily recognized; when they are difficult to observe a dry mount of the spores will often be of considerable help in recognizing and distinguishing them, but interpretation of the types of markings is frequently a rather difficult task. In order to harmonize descriptions of various species having the same type of markings it has seemed best to limit the use of some terms, especially the terms *verrucose* and *echinulate*. The word *verrucose* is applied to those markings which are wart-like and have rounded apices. Markings on aeciospore-walls are usually of this type. The word *echinulate* is used in describing those markings which are needle-like or spiny with more or less sharply-pointed apices. Urediniospore-walls frequently have markings of this type. These markings are placed at various distances apart and in order to insure conciseness and harmony in describing the various species,

the following scheme is used. Those markings which are 1 μ or less apart are described as *very close*, those which are 1μ to 2μ apart are called *close*, 2μ to 3μ apart *moderate*, 3μ to 5μ apart *sparse* and 5μ or more apart *very sparse*. This scheme is used merely as a guide in writing up descriptions and ordinarily no attempt is made to measure the distances between the markings.

THE PORES

The number, position, and character of pores, especially in urediniospores, have shown themselves to be exceedingly valuable features in defining and distinguishing species. To any one who questions this statement the writer desires, for example, to point out the three species of grass rusts, *Puccinia Clematidis* (*P. triticina*), *P. glumarum*, and *P. montanensis*, which are usually accepted as good species. A study by the writer of the material of these rusts in the Arthur herbarium has shown that such characters as type of spotting (frequently a difficult thing to distinguish in dried specimens), linear arrangement of sori, and other features are often found to be associated with at least two and sometimes all three of these closely related species. When telia are present, *P. montanensis* may readily be distinguished from the other two, but when uredinia only are available, the writer has found that the best distinguishing character is the number of pores in the urediniospore-walls, which is 6 to 8 in *P. Clematidis*, 8 to 10 in *P. montanensis*, and 10 to 15 in *P. glumarum*. (It is beyond the scope of this paper to give further details on these rusts.)

Frequently the pores are difficult to locate and to count, as in the three rusts mentioned above, especially if the wall coloring is too faint or too dark or if the cell contents is made up of oil globules or other refractive bodies. The easiest way of distinguishing pores from spore inclusions is to obtain the pores in optical section when they will appear as passage-ways in the wall. Then by rotating the spore, which is done by gently tapping or moving the cover-glass, the number and position of pores can be ascertained. When the walls are densely colored the use of lactic acid and heat is very helpful in bringing out the pores, and when the walls are lacking in color the use of chloral-hydrate-iodine, of the formula given by Stevens in his Plant Anatomy, p. 300, is frequently very beneficial. By these methods there are very few species of rusts in which urediniospore- or teliospore-pores cannot be ascertained.

No attempt is here made to discuss all the characters and terminology used in describing rusts in the Arthur herbarium but rather to explain the methods used in studying the more obscure characters.

UNIVERSITY OF ARKANSAS
AGRICULTURAL EXPERIMENTAL STATION

PHYTOPATHOLOGICAL NOTES

An epidemic of corn smut following hail. There is a small district of some six by ten miles directly east of Greeley, Colorado, where hail storms occur frequently, and often with severity. On the afternoon of July 29, 1918, a storm occurred which did much damage. Beans were pounded into the ground and killed outright; sugar beets and potatoes were defoliated; corn was badly bruised and the leaves shredded. On August 14, sixteen days after the storm, several fields of smutted corn were observed averaging 19 per cent infection. Other fields outside of this hail area, but subject to high winds, averaged only 1 per cent infection. According to testimony of the farmers owning the corn, the smut (*Ustilago zeae* (Beckm.) Unger) had appeared following the hail, and none had been observed before it. It is safe to assume that the fields contained at least the 1 per cent commonly found. This would have provided a source of infection.

Hail storms in this region are usually preceded by wind and rain. Little or no wind may accompany the hail, though some rain usually falls for the first few minutes. A severe hail such as occurred on July 29 would easily have broken and shattered any smut sporophores and scattered the spores or raised them in clouds. Presumably wind accompanied this storm, though there is no definite information on this point.

The smut boils as seen on August 14 were of remarkably uniform size. They were about two inches in diameter and beginning to break down into conidia. In spite of the fact that the corn plants showed abundant bruises and shattered leaves, infection had taken place only at the leaf axils. There was no infection through wound or bruise. Piemeisel[1] has reported that infection may take place readily without injury of the tissues, and is purely local. He makes no mention of having caused infection through wounds. Potter and Melchers,[2] however, consider that the conidia do not infect directly, but that infection results from the development of a virulent culture in the leaf axil. As noted above, infection following the hail was evidenced only at the leaf axils. This infection was probably as general and violent as ever occurs in nature. It seems reasonable to suppose that the wounds on the corn plant were liberally sown with smut spores, and that direct infection might have followed had direct in-

[1] Piemeisel, Frank, J. Some facts of the life history of *Ustilago zeae* (Beckm.) Unger. Phytopath. **4,** No. 6: 411–412. December, 1914.

[2] Potter, Alden A., and Melchers, Leo E. Ecological observations on *Ustilago zeae*. Phytopath. **40,** No. 1: 73–74. February 191[illegible]

fection been the rule. The answer to this may be that at the axil only would enough moisture collect to cause spore germination and make fungous growth readily possible, especially in an arid climate.

H. G. MACMILLAN.

Plant pathologist desired in Brazil. A communication from Mr. Adolph Hempel (Secretaria da Agricultura, Commercio e Obras Publicas, do Estado de S. Paulo, Directoria de Agricultura, Brazil) states:

"The State Government wishes to install a new department of economic entomology and plant pathology, and would prefer to have men from North America and some that have had some experience in their specialties and who are capable of doing research work, and who would be willing to work under my direction here in S. Paulo, and contract for several years, at a salary of about $150.00 a month, and traveling expenses paid."

Personals. Mr. Fred C. Werkenthin has resigned his position as assistant professor of biology at the New Mexico College of Agriculture and Mechanic Arts to accept a position as associate professor of botany at the New Hampshire Agricultural College.

Dr. Charlotte Elliott of Dell Rapids, South Dakota, has been appointed as assistant pathologist in the Laboratory of Plant Pathology, Bureau of Plant Industry.

Mr. G. H. Martin, Jr., formerly a teaching fellow in plant pathology at the University of Washington, has accepted the position of plant pathologist in the Plant Disease Survey, Bureau of Plant Industry.

Dr. V. H. Young has resigned his position in the Office of Cotton, Truck, and Forage Crop Disease Investigations, Bureau of Plant Industry, to become the head of the department of botany in the University of Idaho.

Dr. F. A. Wolf, for several years in charge of the botany and plant pathology work at the North Carolina Agricultural College and Experiment Station, has been given a commission as first lieutenant in the sanitary corps of the Army.

LITERATURE ON PLANT DISEASES[1]

COMPILED BY EUNICE R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY, AND FLORENCE P. SMITH, ASSISTANT

August, 1918

Africa, Emilio Macasaet. The minimum Bordeaux application for the control of Hemileia. Philippine Agr. and Forester **6:** 251–271. My. 1918.
Bibliography, p. 271.
Thesis.

American Phytopathological Society. Cereal pathologists. Fourth annual field conference . . . Science, n. s. **48:** 148–150. Ag. 8, 1918.

Boyce, J. S. Advance rot and latent defects on aeroplane timber. Aerial Age Weekly **7:** 674–675, 691. Je. 17, 1918.
Bibliography, p. 691.

Brierley, William Broadhurst. The microconidia of Botrytis cinerea. Roy. Gard. Kew, Bul. Misc. Inform. **1918:** 129–146, pl. My. 1918.

Cook, Melville Thurston. Common diseases of berries. New Jersey Agr. Expt. Sta. Circ. 88, 11 p., illus. [1918?]

——— Common diseases of garden vegetables and truck crops. New Jersey Agr. Expt. Sta. Circ. 89, 22 p., illus. [1918?]

——— and **Martin, William H.** Leaf blight of the tomato. New Jersey Agr. Expt. Sta. Circ. 96, 4 p., illus. 1918.

Dodge, Bernard Ogilvie. Studies in the genus Gymnosporangium. II. Report on cultures made in 1915 and 1916. Bul. Torrey Bot. Club **45:** 287–300, pl. 8. Jy. 1918.
Literature cited, p. 299.

Edson, Howard Austin, and **Shapovalov, Michael.** Potato-stem lesions. Jour. Agr. Research **14:** 213–220, pl. 24–26. Jy. 29, 1918.

Elliott, John Asbury. Arkansas peach diseases. Arkansas Agr. Expt. Sta. Bul. 149, 9 p., 5 pl. 1918.

Grove, William Bywater. The British species of Melanconium. Roy. Gard. Kew Bul. Misc. Inform. **1918:** 161–178, illus. Je. 1918.

Hall, Constant Johan Jacob van. De bescherming der cultuurgewassen tegen nieuwe ziekten en plagen uit het buitenland. Teysmannia **29:** 62–95. 1918.
Reprinted.

[1] This list includes references, both American and foreign, to the literature of plant pathology and mycology of interest to pathologists. Foreign references published since January 1, 1917, have been included beginning with the list appearing in v. 7 no. 3, June 1917.

All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

Harreveld, Philippe van. Stambibittuinen en zeefvatenziekte. Arch. Suikerindus. Nederl. Ind. **26:** 333–346. 1918. (Meded. Proefstat. Java-Suikerindus. Landb. Ser. 1918, no. 4.)

Harter, Leonard Lee. A hitherto-unreported disease of okra. Jour. Agr. Research **14:** 207–212, illus., pl. 23. Jy. 29, 1918.

Ascochyta abelmoschi n. sp.

Kezer, Alvin, and **Sackett, Walter T.** Beans in Colorado and their diseases. Colo. Agr. Expt. Sta. Bul. 234, 32p., illus. 1918.

Revised edition of bulletin 226.

Lindfors, Thore. Mykologische notizen. Svensk Bot. Tidskr. **12:** 221–227, illus. Je. 15, 1918.

1. *Caeoma interstitiale* Schlecht. und *Puccinia peckiana* Howe. 2. Zwei neue Spezies der Gattung Protomyces. 3. *Helminthosporium acrothecioides* n. sp.

Lint, Henry Clay. Seed and soil treatment for the control of potato scab. New Jersey Agr. Expt. Sta. Circ. 95, 4 p., illus. [1918.]

Massey, Louis Melville. The diseases of roses. Trans. Mass. Hort. Soc. **1918,** pt. 1: 81–101, pl. 1–2. 1918.

Bibliography, p. 100–101.

Matz, Julius. Diseases and insect pests of the pecan. Florida Agr. Expt. Sta. Bul. 147: 133–163, illus. My. 1918.

Ness, H. Field experiments with crown gall. Texas Agr. Expt. Sta. Bul. 211, 21 p., illus. 1917.

Noffray, E. Cryptogamiques nuisibles aux cucurbitacées. Jour. Agr. Prat. n. s. **31:** 277–278. Jy. 11, 1918.

Blanc du houblon (*Sphaerotheca castanei*); blanc des polygonées (*Erysiphe polygoni*).

Palm, Björn. Sur une plasmodiophoracée nouvelle, Ligniera isoëtis. Svensk Bot. Tidskr. **12:** 228–232, illus. Je. 15, 1918.

Tanaka, Tyôzaburô. Notes on some fungous diseases and a new codling moth attacking the persimmon in Japan. Mo. Bul. State Com. Hort. [California] **7:** 461–463. Jy. 1918.

Abstracted from recent Japanese literature.

Gloesporium kaki n. sp.; stem rot, *Myxosporium kaki* n. sp. and *Phoma lutii*: *Mycosphaerella diospyri* (*Cercospora kaki*); *Fusicladium diospyrae* n. sp.; *Pestalozzia kaki*, etc.

U. S. Department of Agriculture. Bureau of Plant Industry. Plant Disease Survey. Plant disease bulletin 2: 81–99, Jy. 15; 100–119, Ag. 1. 1918.

——— **Federal Horticultural Board.** Service and regulatory announcements. June: 63–69. Ag. 7, 1918.

[PHYTOPATHOLOGY for October, 1918 (**8:** 507–555) was issued November 7, 1918]